



## National Wildfire Coordinating Group Communicator's Guide for Wildland Fire Management: *Fire Education, Prevention, and Mitigation Practices*

### 2. Wildland Fire Overview

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#### **Wildland Fire Overview**

This chapter outlines the basic information communicators should know about wildland fire in order to effectively communicate this complex topic to various audiences. A concise section on the science of wildland fire and its role in ecosystems is included as background information. You can craft meaningful messages using this information, your existing knowledge, and the science of wildland fire in your particular area.

## Introduction

Wildland fire is any non-structure fire that occurs in an area in which development is essentially non-existent, except for roads, railroads, power lines, and similar transportation facilities. Three distinct types of wildland fire have been **defined** by the **National Wildfire Coordinating Group (NWCG)**:

- **Wildfire:** An unplanned, unwanted wildland fire including unauthorized human-caused fires, escaped wildland fire use events, escaped prescribed fire projects, and all other wildland fires where the objective is to put the fire out.
- **Wildland fire use:** The application of the appropriate management response to naturally-ignited wildland fires to accomplish specific resource management objectives in pre-defined designated areas outlined in Fire Management Plans.
- **Prescribed fire:** Any fire ignited by management actions to meet specific objectives, e.g., the establishment/maintenance of healthy forests and grasslands or the enhancement of certain wildlife habitat. Prescribed fire is a well-established practice on public and private lands throughout the world, and is based on years of scientific research. Resource managers carefully calculate meteorological factors, fuels, slope of land, and other relevant conditions in planning prescribed fires. Utmost care is taken to protect human life and property, manage impacts of smoke, protect historical and archeological resources, and protect the ecological integrity of the physical and biological resources.

An excellent resource for a more detailed understanding of fire behavior concepts is the [NWCG course S-190: Introduction to Wildland Fire Behavior](#).



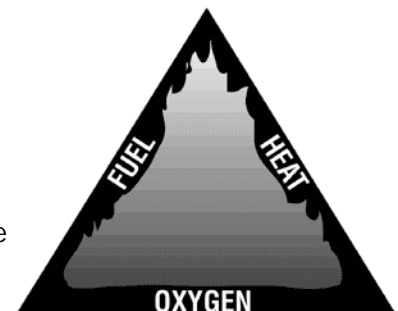
When communicating about wildland fire management issues, it is important to be aware of the basic scientific tenets of wildland fire, including the combustion process and the factors influencing wildland fire behavior. This chapter is intended to provide you with an overview of these topics.

## Ecological Aspects of Wildland Fire

Depending on the expertise of the audience, you may choose to limit the discussion to a simple overview of the fire triangle, or expand the discussion to include the technical details of flame structure and fuel chemistry. This section is intended to provide you with an overview of the scientific processes occurring with wildland fires.

### The Fire Triangle

The first step in teaching about wildland fire is to begin with the essentials as illustrated by the fire triangle and its three equal components: heat, fuel, and oxygen. The interaction of all three is required for the creation and maintenance of any fire. When not enough heat is generated or when water is used to reduce the heat level; when the fuel is exhausted, removed, or isolated; or when the oxygen supply is limited, then a side of the triangle is broken and the fire is extinguished. The underlying concept is that wildland fire personnel seek to manage one or more of the three elements to suppress an unwanted fire or guide a prescribed fire.



## Heat

A heat source is needed for the initial ignition of wildland fires. Heat is also generated by the fire. Heat transfer is a critical issue in the study of wildland fire. For a fire to grow and spread, heat must be transferred to the initial and surrounding fuel. Heat allows fire to spread by removing (evaporating) the moisture from the nearby fuel, enabling it to ignite or travel more easily. The mechanism and the speed of heat transfer play a great role in wildland fire behavior.

Three mechanisms of heat transfer exist: convection, radiation, and conduction. All three contribute in different ways to the combustion process, depending in part on the fuel distribution, the wind speed at the fire site, and the slope of the terrain.

- **Convection** is the transfer of heat through the flow of liquids or gases, such as when hot air rises through a chimney. Convection currents are often responsible for the preheating of the higher shrub layers and canopy, carrying the ground fire upwards into the canopy.
- **Radiation** transmits heat by rays, such as from the sun or a flame. Radiation accounts for most of the preheating of fuels surrounding a fire. The temperature of these fuels can sometimes rise so high that the fuels ignite prior to contact with flames, spreading the fire.
- **Conduction** moves heat from one fuel particle to the next, as when the stove burner heats a pan and its contents. Conduction allows the heat to be transferred inside and throughout the fuel, rather than only heating the surface. Because wood is a poor heat conductor, meaning heat does not pass through it easily, conduction is usually not the primary mechanism of heat transfer in a wildland fire.

Helping your audience(s) understand the fire triangle concept is critical to helping them understand why certain actions are taken. Without this understanding, especially in a suppression situation, firefighters' actions may be misunderstood.

## Fuel

The fuel side of the fire triangle refers to both the external and internal properties of the fuel. External properties refer to the type and the characteristics of the fuel material. Internal properties of fuel address aspects of fuel chemistry. Fuel is characterized by its moisture content, size and shape, quantity, and the arrangement in which it is spread over the landscape.

- The **moisture content** of any fuel will determine how easily that fuel will ignite and burn. Live trees usually contain a great deal of moisture while dead logs contain very little. Before a wet fuel can burn, the moisture must be converted to vapor through the heat process. The greater the moisture content, the higher the heat temperatures required to dry the fuel. The presence of moist fuel can affect the rate and direction that a wildland fire spreads. High moisture content slows the burning process since heat from the fire must first expel moisture.
- The **size and shape** of fuel in part determines its moisture content. Lighter fuels such as grasses, leaves, and needles quickly dry out, and therefore burn rapidly. Heavier fuels, such as tree branches, logs, and trunks, take longer to warm and ignite. In areas of light fuel, the temperature required for ignition is lower than in areas of heavier fuel. The oxygen surrounds lighter fuels and allows the fuel to burn with greater intensity, quickly exhausting the fuel supply.

Types of fuel include living vegetation, dead vegetation, (duff, twigs, needles, standing dead snags, leaves, and moss), organic subsurface material (peat and coal), and human built structures. Fuel can be defined as any combustible material.

- The **quantity** of combustible fuel in a given area is known as fuel loading. These fuels may be arranged in a uniform pattern and distributed continuously across the ground, allowing a wildland fire to travel uninterrupted. Or, the fuel may be distributed unevenly in a patchy network, forcing the fire to travel over rocks and other barriers by wind-borne embers.
- The **vertical arrangement** of fuel is also an important factor in wildland fires. Ground fuels are all of the combustible materials found below the ground surface, and include tree roots, duff, and organic material. Surface fuels are found at the ground level, including twigs, grass, needles, wood, and other vegetation. Ladder fuels are just above ground level such as tall grass and bushes and can carry flames into the tops of trees. Aerial fuels are standing vegetation including tree crowns, branches, leaves, snags, and hanging moss. Crown fires are able to burn independently of surface fires, moving through the treetops.

### ***Oxygen***

The third side of the fire triangle represents oxygen. Air contains about 21% oxygen; most fires require air with at least 16% oxygen content to burn under most conditions. Oxygen supports the chemical processes that occur during a wildland fire. When fuel burns, it reacts with oxygen from the surrounding air, releasing heat and generating combustion products, e.g., gases, smoke, particles. This process is known as oxidation.

### **Fire Behavior**

All wildland fires begin with an ignition source. Lightning is a common ignition source of wildland fires. Nine out of ten fires, however, are started directly or indirectly by people, through debris burning, campfires, arson, discarded smoking products, sparks from equipment in operation, arced power lines, and other means. Fire behavior describes the manner in which fuels ignite, flames develop, and fire spreads. The fundamental influences on the spread of wildland fire include fuel type and characteristics, weather conditions in the area, and topography.

### ***Fuel***

Because of the complicated combustion process that occurs during the ignition and spread of a wildland fire, it may be useful to describe to your audience the difference between fire and flame. Fire is a chemical reaction, and flame is the visible indication of that chemical reaction. When a flame is visible, the combustion is termed “flaming combustion.” With “glowing combustion” one will only see embers.

Fuels char at relatively low temperatures, but once charred can continue to burn by glowing combustion. As fire spreads, there is constant ignition of new fuels through one of the three heat transfer mechanisms described earlier, and the fire continues to advance.



### ***Weather***

Weather is the most variable of the factors that affect fire behavior. Wildland fires are affected by wind, temperature, and humidity in the burn zone. Strong winds can affect fire behavior by pushing the flames toward new fuel sources. Wind is able to pick up and transfer burning embers, sparks, and other materials that are capable of starting “spot fires.” Blowing wind can also serve as a fuel drying source in moist areas. Wildland fires are capable of generating their own wind. Air above the hot flames becomes heated, causing it to rise. This movement allows fresh air to fill the vacuum provided; this fresh air supplies the fire with a fresh supply of oxygen. In essence, fires can generate their own winds, fanning their own flames.

During the day, sunlight heats the ground and the warm air rises, allowing air currents to travel up sloped landscapes. At nightfall, the process is reversed. The ground cools and the air currents now travel down the slopes. Often fires will burn upslope during the day and down slope at night. Temperature acts upon the spread of wildland fires because the temperature of the fuel affects how quickly or slowly they will reach their ignition point and burn. Because fuels are also heated by solar radiation, fires in the shade will not burn as quickly as those in the direct path of sunlight.



Humidity is a measure of the amount of moisture in the air. This moisture dampens the fuel, slowing the spread of flames. Because humidity is greater at night, fires will often burn less intensely at that time under normal circumstances, and therefore will not travel a great distance.

The combination of wind, temperature, and humidity affects how fast wildland fires can spread. These combinations will change throughout the day and night, and the presence of fire will impact each factor, causing even greater variation.

### ***Topography***

Topography of a landscape also affects the spread of wildland fire. Every wildland fire is different in the way that it behaves because of the changing combinations of so many factors, but topography remains constant and therefore allows for more constant predictions of how fire will behave in a specific area.



An explanation of topography includes the shape of the landscape, its elevation, the slope direction and its exposure to sunlight, and the slope steepness (aspect).

- The shape of the land determines how much sunlight or shade an area contains, affecting temperature and wind conditions. Certain fuels grow better under different conditions. In addition, if the landscape has barriers, including highways, boulders and rock slides, or bodies of water, the fire will not spread as quickly.
- Elevation and slope direction affect the type and temperature of the fuel to the degree in which there are shaded and sunny areas. Elevation also impacts how much wind and moisture the area receives.
- The amount of shade or sunlight, the temperature of an area, and moisture received by an area all determine the type of fuel available for wildland fires.
- Slope steepness is important in that it contributes to how quickly the fire will reach the crest of the land form. When a fire begins at the bottom of a slope, the fuels located uphill are preheated by the rising air, helping them to easily catch fire when they come in contact with flames. Fires that begin uphill may deposit burning material that rolls downward, allowing more fires to begin downhill.

### **The Complexity of the Fire Message**

While helping your audience understand the basic concepts of fire, it is critical to convey the complexity. The science behind wildland fire requires knowledge of chemistry, physics, geology, meteorology, and ecology. That knowledge is then interpreted to help predict and explain fire

behavior. Each situation is different in that fire does not function within the framework of a static model.

Wildland fire, as it moves, involves a changing situation. Fire itself changes its own environment, e.g., winds. In essence, in managing a fire the professionals are mixing a recipe in which the ingredients are known but the quantities going in and out of the recipe are constantly changing as is the heat. Such analogies may help your audience better understand why wildland fire management is a demanding art and a science.



## Defining Fire Regimes

Wildland fire is a natural process, and many ecosystems depend upon it. As we tell the story of fire to illustrate the science of wildland fire management, we also need to tell stories that promote coexistence with wildland fire. In discussing and addressing fire as a conservation issue, it is important to recognize and understand the different roles that fire plays in different ecosystems. The broad ecosystem categories of vegetation responses to fire below can be helpful in communicating general concepts to the public.

- **Fire-dependent ecosystems** are those where fire is essential and the species have evolved adaptations to respond positively to fire and to facilitate fire's spread, i.e. the vegetation is fire-prone and flammable. They are often called **fire-adapted** or **fire maintained** ecosystems. Many plants and animals in these landscapes depend on fire to reproduce and grow. If fire is removed, or if the fire regime is altered beyond its normal range of variability, the ecosystem changes to something else, and habitats and species are lost. Fire dependent ecosystems vary greatly and need to burn under an appropriate fire regime if they are to persist in the landscape.
- **Fire-sensitive ecosystems** have not evolved with fire as a significant, recurring process. In these ecosystems, most plants and animals lack adaptations to respond to fire and generally lack the ability to rebound after wildfire. Vegetation structure and composition tend to inhibit ignition and fire spread. A wide variety of fire-sensitive ecosystems in the tropics and elsewhere are threatened by land use activities and vegetation conversion efforts that either use fire or increase the probability of ignitions.
- **Fire-independent ecosystems** are those where fire normally plays little or no role. They are too cold (tundra), too wet (rain forests), or too dry (deserts) to burn. Fire becomes a threat only if there are significant changes to these ecosystems brought about by land use activities, species invasions, or climate change.

As communicators, the questions we must be able to answer for the public are: "What ecosystem type or vegetation structure are we trying to conserve and/or manage?" and "Are the fires that are occurring in that ecosystem helping to maintain it or are they causing the ecosystem to change?"

It is important for you and your audience to understand that fire regimes, like the entire natural world, are diverse and particular to their specific sites. Fire helps determine where different types of habitats exist around the world. Plants and animals have developed different responses to fire, with some dependent on fire and others sensitive to fire.

**A fire regime** is a set of recurring conditions of fire that characterizes a given ecosystem. The combination of fire frequency, intensity, severity, seasonality, size of burn, fire spread pattern, and pattern and distribution of burn circumscribe those conditions. Fire regimes can often be described as cycles because some parts of the histories usually get repeated, and the repetitions can be counted and measured, such as fire return interval.

An **ecologically appropriate fire regime** is one that maintains the viability of the ecosystem.

An **altered or undesirable fire regime** is one that has been modified by human activities to the extent that the current fire regime negatively affects the viability of desired ecosystems and the sustainability of products and services that the ecosystem provides.

Although fire is one of the most important natural disturbances in many of the Earth's ecosystems, inevitably, conservation practitioners addressing fire issues find that they must also deal with other threats or issues that, because they affect fuels, alter fire regimes. We cannot effectively restore ecologically acceptable regimes unless we also understand and address the underlying causes of alteration. Some general sources are listed below; however, you may have a source unique to your particular area that you need to communicate to your audience.

- Climate change
- Grazing or other land management practices
- Landscape fragmentation
- Rural and urban growth
- Arson
- Lack of or inappropriate fire management practices
- Crop production or non-compatible timber practices
- Invasive species or insect disease
- Loss of traditional and cultural fire use practices that promoted appropriate fire regimes
- Ecosystem conversion
- National policies

In many ecosystems, fire regime alteration is a slow and incremental process, sometimes occurring over decades, and is often linked to multiple sources of degradation related to the many ways that people utilize and interact with our landscapes. Therefore, the attention of the public and decision-makers often occurs after a triggering event, like prolonged drought and uncharacteristically severe fires.

### **Fire Regime Condition Class**

Fire regime condition class (FRCC) is a standardized, interagency tool for determining the degree to which current vegetation and fire regime conditions have departed from historical reference conditions.

<b>The Five Historic Natural Fire Regime Groups</b>		
<b>Fire Regime Group</b>	<b>Frequency (Fire Return Interval)</b>	<b>Severity</b>
I	0-35 years	Low severity
II	0-35 years	stand replacement severity
III	35-100+ years	mixed severity
IV	35-100+ years	stand replacement severity
V	>200 years	stand replacement severity

The fire regime groups are intended to characterize the presumed historical fire regimes within landscapes based on interactions between vegetation dynamics, fire spread, fire effects, and spatial context. You can access fire effects/fire ecology data to learn more about fire regime characterizations and summaries on plant, animal, and vegetation communities for your specific area by exploring the Fire Effects Information System (FEIS; [www.fs.fed.us/database/feis/](http://www.fs.fed.us/database/feis/)).

Condition class attributes is an approach to defining and interpreting the importance of fire frequency in ecosystems. This concept is useful in helping wildland fire communicators convey to their audiences the science and management behind wildland fire.

Current "condition class" is defined in terms of departure from the historic fire regime, as determined by the number of missed fire return intervals with respect to (1) the historic fire return interval, and (2) the current structure and composition of the system resulting from alterations to the disturbance regime.

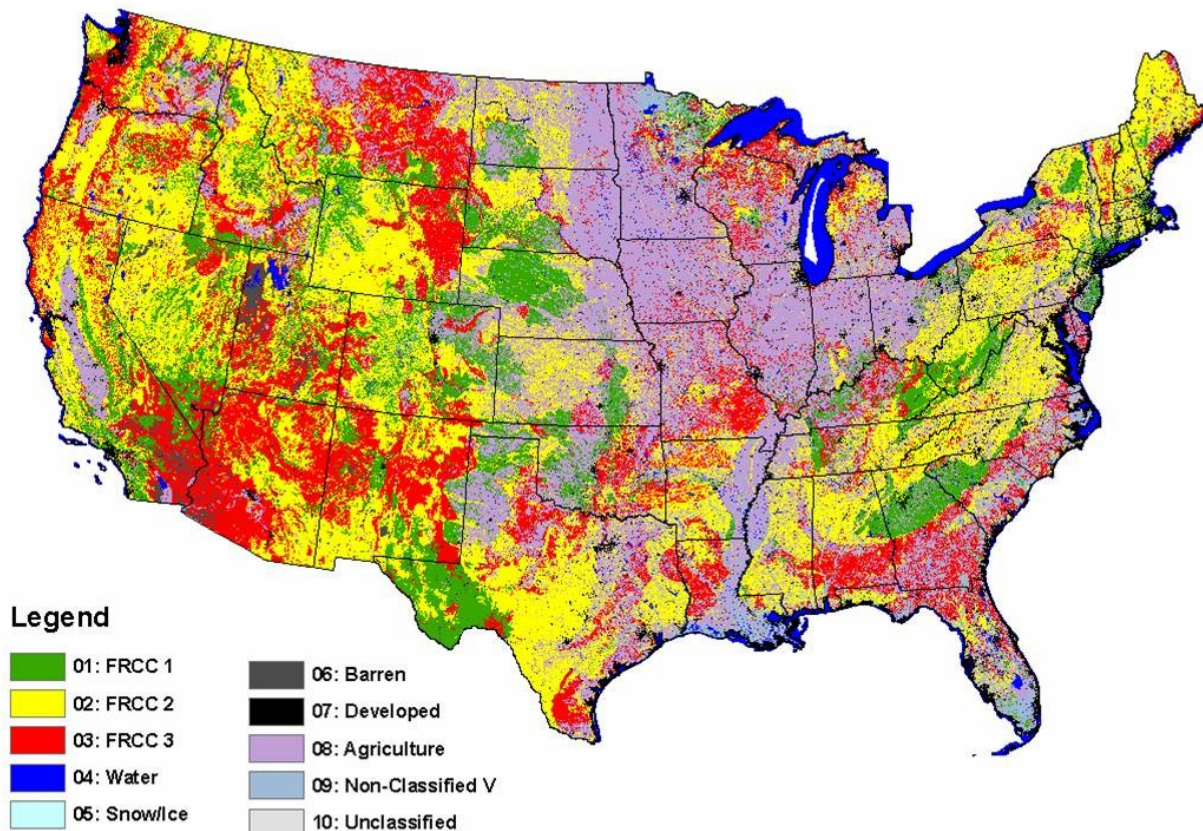


Three “condition classes” have been developed to categorize the current condition with respect to each of the five historic Fire Regime Groups.

- **Fire Regime Condition Class 1:** For the most part, fire regimes in this Fire Regime Condition Class are within historical ranges. Thus, the risk of losing key ecosystem components from the occurrence of fire remains relatively low. Maintenance management such as wildland fire use and/or prescribed fire, mechanical treatments, or preventing the invasion of non-native weeds, is required to prevent these lands from becoming degraded.
- **Fire Regime Condition Class 2:** Fire regimes on these lands have been moderately altered from their historical range by either increased or decreased fire frequency. A moderate risk of losing key ecosystem components has been identified in these lands. Restoring these lands to their historical fire regimes may require some level of restoration through the use of fire, mechanical or chemical treatments, and the subsequent reintroduction of native plants.
- **Fire Regime Condition Class 3:** These lands have been significantly altered from their historical range. Because fire regimes have been extensively altered, risk of losing key ecosystem components from fire is high. Consequently, restoring these lands to their historical fire regimes may require multiple mechanical or chemical treatments and reseedling before some application of fire such as prescribed fire can be utilized to manage fuel or obtain other desired benefits.

A complete definition, background information, and the nationally consistent methodology for calculating and mapping FRCC are available at [www.frcc.gov](http://www.frcc.gov).

## LANDFIRE Rapid Assessment Fire Regime Condition Class



***Map generated from LANDFIRE Rapid Assessment data.***

LANDFIRE is a multi-partner wildland fire, ecosystem, and wildland fuel mapping project. LANDFIRE's objective is to provide consistent, nationwide data describing wildland fuel, existing vegetation composition and structure, historical vegetation conditions, and historical fire regimes. For detailed information and additional maps and products go to [www.landfire.gov](http://www.landfire.gov).

## Fire Dependent Ecosystems of the United States

A central tenet for communicators is “relate to your audience.” Historically, most terrestrial ecosystems in the United States were dependent to some extent upon fire. Addressing wildland fire using local examples has the potential to better help people relate. **Seven major ecosystems** are used as examples of how to concisely frame local descriptions.

Ecosystems, or ecological communities, are geographic areas containing similar biological communities and abiotic conditions, such as temperature, rainfall, and seasons. They are tied through flows of energy. These ecosystems are often identified by the dominant plant communities found in the region. The plant species found in these biological regions are a function of many factors, including climate, interactions among species, and disturbance regimes such as fire. Fire occurs in nearly all terrestrial ecosystems, however, in some ecosystems wildland fire is one of the major factors in determining community structure and composition.

Fire disturbance regimes can be characterized by the following:

- Effects of disturbance agents
- Potential production of smoke emissions
- Hydrologic functioning
- Vegetative composition, structure, and resilience

Wildland fire occurs naturally and plays varying roles in nearly all ecosystems. Because different types of ecosystems produce and accumulate fuel more quickly than others, the wildland fire frequency and intensity are determined by the type and the stage of development of the ecosystem in which it occurs. Depending on the fire regime, many species evolve adaptation to fire, making fire important for competition with other species, or even necessary for reproduction. Fire, in a natural or prescribed form, is important to the maintenance and health of most ecosystems.

The community structure and species composition at any given site are responses to various aspects of disturbance. Over time, disturbances such as flood, drought, and fire have molded the composition, structure, and ecological processes of the world's ecosystems.

Organisms within these ecosystems have evolved to survive the disturbance patterns unique to an area. Species adaptations to disturbances can be thought of as the evolution of physical and behavioral traits which allow for reproduction and the continuance of a species. Many plant species have important adaptations that allow them to survive, thrive, and even require fire for survival. However, it is important to recognize that not all adaptations that protect plants are a response to fire, but may be a response to other pressures, such as grazing or drought. Following is a summary of plant species adaptations to fire.

- **Protection.** Many plants have characteristics that protect them as a species from being extirpated by wildland fire, i.e., fire resistant adaptations. The most common example of fire protection is the thick bark on some species of trees in fire maintained ecosystems, such as ponderosa pine and bur oak. In addition, some species have protective coverings over critical plant parts. Examples of these coverings are the needle and scale coverings over the buds on longleaf pine, and the below-ground meristem tissue (where growth occurs) in grasses.
- **Growth.** Several adaptations relate plant growth to fire, i.e., growth-related adaptations. Some trees, such as ponderosa pine, actually increase their growth rate in the years following a fire. This response is visible in the annual rings in the cross section of trunks. Other growth-related adaptations include dormant buds that begin growing after limbs and branches are burned away, stimulation of suckering from the stumps of burned trees, and lignotubers (dormant below-ground buds in some legumes).
- **Reproduction.** Several reproductive-oriented adaptations allow plants to take advantage of, or even require, wildland fire. Fire has been shown to trigger and/or increase seed release in some species, such as lodgepole and jack pines, and to stimulate flowering and fruiting in

some shrubs and herbs. Some seeds remain dormant until the seedcoat is scarified, or cracked, which can result from intense heat or fire. Some pines have serotinous cones, in which the seeds are sealed in the cone by a waxy pitch that requires fire to remove the seals and free the seeds for germination.

- **Germination.** Fire can also prepare seedbeds for germination by burning leaf litter. Some seeds require mineral soil for germination, and fire can release nutrients in the soil and make them available for sprouting plants. Likewise, fire can remove overstory plant material permitting sunlight to reach understory plants.

These adaptations, in combination with the local fire regime at a specific site, play an important role in determining the composition of the plant community.

### **Impact on Animals**

The immediate impact of wildland fire on animals is generally less intense, as both vertebrates and invertebrates have been shown to be fairly successful at avoiding being burned in fire. However, major changes in the plant communities following a fire have significant impacts on the animal communities that inhabit these ecosystems.

Over time, however, the impacts of human generated fire or suppression of fire can have major consequences for animals. For example, the movement of American bison to the eastern United States in the 1500s may have resulted from Native Americans burning in the east which opened more grazing for bison. Recent studies of ancient Aboriginal “fire-stick farming” practices in Australia beginning 50,000 years ago suggest fire impacts as the reason for extinction of certain large animals.

### **Overview of Fire Dependent Ecosystems**

It is essential for you to stress the importance of fire on ecosystem health, and to inform audiences that wildland fire management practices for one ecosystem are not necessarily appropriate for another. This section provides a brief overview of fire-dependent ecosystems within the United States to illustrate how to frame stories when communicating with audiences about the role of fire.

#### **Midwest Tallgrass Prairie**

Historically, tallgrass prairies covered a large portion of the midwest. To the west, the tallgrass prairie graded into shortgrass prairie. To the east, the tallgrass prairie included increasing numbers of trees, first as scattered oak savannahs and gallery forests, eventually becoming forests with prairie openings. These extended eastward into the Ohio Valley.

Tallgrass prairie is primarily made up of grasses and forbs, with some shrubs and trees. Prairie plant communities are a result of fire and drought, although some community structure is in part from grazing by bison and elk. Drought acts both as a direct and indirect stress on the prairie ecosystem because it dries potential fuels and increases the chances that fire will occur. In pre-Colombian times, natural fire sources were primarily from lightning

Sequoias depend on frequent fire. Fire prepares the ground with nutrient-rich ash on mineral soil so sequoia seeds can germinate.



Nature Conservancy Tallgrass Prairie Preserve, Oklahoma © Harvey Payne



strikes, although there is evidence that deliberate fires started by Native Americans were also common. Fires in the prairie usually occurred in five- to ten-year cycles, with moderate regularity. Fire in tallgrass prairies acts to burn above-ground biomass, killing woody plants, allowing sunlight to reach the soil, and changing the soil pH and nutrient availability. Grassland fires can cover large areas in a short time as fire fronts are driven by prairie winds. However, because grass provides a low quality of fuel, grassland fires usually are not intense.

Productivity usually increases following a fire in the prairie. Growth is stimulated by the removal of litter and preparation of the seedbed. In addition, perennials have greater seed production, germination, and establishment after a fire. The seeds of some forbs, such as prairie sunflower, scarify and leave dormancy following fire. Growth of native species such as big bluestem, little bluestem, and Indian grass all increase significantly following a fire. Fire promotes grasses at the expense of woody species; woody species that occur in savannahs are usually thick-barked species such as bur oak. Because of predominantly westerly winds across American prairies, trees are sometimes found on the eastern bank of streams and rivers that stop fires spread by these winds.

When fire is removed from a prairie ecosystem, woody shrubs and trees eventually replace grasses and forbs. Mowing is not a good replacement for fire in prairies because it does not reduce litter. Grazing is not a good replacement because livestock eat some grass species while leaving others untouched.

Almost exclusively, burning is prescribed for the restoration and maintenance of prairie reserves. In most managed prairies, prescribed fire is introduced on a two- to three-year cycle. The time of the year during which these fires are ignited is of primary importance. Plant recovery following a prairie fire is fastest in the spring and fall when soil moisture is high and plants are not producing seeds. If the area is burned when soil moisture is low, or when plants are starting to produce seeds, the recovery will take longer following the fire.

### **Southwestern California Chaparral**

Chaparral is a general term that applies to various types of brushland found in Southern California, Arizona, New Mexico, and parts of the Rocky Mountains. True chaparral exists primarily in Southern California and describes areas that have a Mediterranean-like climate with hot, dry summers and mild, wet winters. The chaparral in this region is primarily fire-induced, and grows in soils that are shallow and unable to hold water. Generally, the terrain is steep and displays severe erosion. Variations in species cover throughout the area are attributed to the soil type and exposure, the altitude at which it grows, and the frequency of wildland fires.

Chamise (greasewood) is a common plant in this ecosystem. Other important shrubs include manzanitas, Ceanothus, and scrub oaks. Natural fires occur in 15- to 25-year cycles, with high regularity. Plant growth in southern California chaparral occurs during the wet winter months. This vegetation dries during the dry summer months when winds blow from the inland deserts toward the Pacific Ocean. Fires usually occur during the late summer Santa Ana winds, which are strong (up to 60 mph) and dry. These winds tend to drive fire rapidly through the dry brush.

Plants in this ecosystem are adapted to the Mediterranean climate, local soils, and the fire regime. Fire adaptations include vigorous stump sprouting after fires by many shrubs, including the manzanitas, Ceanothus, and scrub oak. Chamise produces dormant seeds that require fire for scarification; these seeds create a large seed bank during non-fire years. In addition, most chaparral plants seed quickly, usually within three to five years after sprouting. Many of the shrubs, especially chamise, promote fire by producing highly flammable dead branches after about 20 years. Another chaparral plant, Ceanothus, has leaves that are coated with flammable resins. Fires occurring at intervals greater than 20 years are often high intensity because of the large amount of fuel existing

in shrub tops. Many nutrients are locked in the foliage of chaparral plants. Through burning, these nutrients are recycled back into the soil.

After fires in chaparral, forbs are usually profuse on the newly opened floor. After a year, the plant community is dominated by annual grasses. Five years after a fire, chaparral shrubs once again dominate the ecosystem. For this reason, more frequent fires favor grasses over shrubs. Fire has not been successfully removed from this ecosystem, so how the community would respond to lack of fire is not well-known, although non-fire adapted trees and shrubs might replace the chamise, manzanita, and Ceanothus.

Wildland fire control in the southern California chaparral ecosystem is very difficult because of the existence of Santa Ana winds, the length of the summer season, and the heat and dryness present throughout the season. This ecosystem contains water-repellent soils, loose surface debris, and steep terrain, all adding to the high risk of unwanted wildland fire. Obstacles to using prescribed burning include the nearness of housing (wildland/urban interface) and the issue of smoke management. Burning also increases the amount of soil erosion, which is especially problematic in developed areas. Some work has been accomplished to replace the chaparral plant community with grasses, but this practice further threatens the existence of the species dependent on this ecosystem.

### **Ponderosa Pine in the Southwest and Intermountain West**

Ponderosa pine ecosystems occur as transitions between grasslands and deserts at lower elevations and higher level alpine communities. These ecosystems are found from the southwestern mountains as far north as Washington and Oregon, and east to the Dakotas, sometimes as nearly pure stands of ponderosa pine, and sometimes mixed with other species, such as Douglas fir. This forest community generally exists in areas with annual rainfall of 25 inches or less.



The characteristic surface cover in a ponderosa pine forest is a mix of grass, forbs, and shrubs. The natural fire regime has a cycle of five to 25 years, with moderate regularity. These fires tend to be low intensity ground fires that remove woody shrubs and favor grasses, creating open, park-like ponderosa stands.

The life history of ponderosa pine is well adapted to high frequency, low intensity fires. These fires burn litter and release soil nutrients, thus providing a good seedbed for ponderosa pine seeds. For the first five years of their life cycle, ponderosa pine seedlings vigorously compete with grasses for survival and are vulnerable to fire. Eventually, at about five or six years of age, the tree begins to develop thick bark and deep roots and shed lower limbs. These factors increase its ability to withstand fire and decrease the possibility of a fire climbing to the crown; crown fires can kill ponderosa pines. Ponderosa needles on the ground facilitate the spread of low intensity ground fires and reduce grasses that can intensify ground fires.

In ponderosa pine stands, fire is generally prescribed on five- to ten-year intervals to reduce fuel loads. Shorter burn intervals have insufficient fuel built up to maintain the fire, and longer periods may run the risk of causing tree-killing crown fires. Prescribed fires usually result in maintenance of stand composition.

Douglas fir is commonly found in association with ponderosa pine, but is able to survive without fire. Additionally, Douglas firs possess characteristics that enable them to withstand fire when it does occur. For example, this species is more resistant to fire than most other conifers. Additionally, the Douglas firs' abundantly produced seeds are lightweight and winged, allowing the wind to carry them



to new locations where seedlings can be established. Douglas fir regenerates readily on sites that are prepared by fire. In fact, nearly all the natural stands of Douglas fir in the United States originated following fire. One of the main benefits of fire in these forest communities is the removal of fuel and consequent reduction of the chance of severe crown fires. Because Douglas fir exists in the presence of other types of trees, the life cycles of many species must be considered when timing a prescribed fire in this type of forest community.

### **Lodgepole Pine Communities of the Rocky Mountains**

Lodgepole pines are found throughout the Rocky Mountains of the western United States, generally in unmixed stands at higher elevations. Major fires occur at intervals of 200 to 300 years in this ecosystem, and these fire events are often high intensity crown fires that kill trees. Each successional stage of a lodgepole pine community displays different reactions to fire.

At 40 to 50 years following a stand-replacing fire, herbaceous plants and lodgepole seedlings grow between snags and logs that were damaged by the fire. The forest tends to resist fire at this stage, in that the only fuels available are large logs that do not readily burn. From the age of 50 to 150 years, seedlings grow to a height of 50 feet, and the stands become so dense that little sunlight reaches the forest floor, therefore suppressing the growth of the understory. The sparseness of undergrowth also discourages the possibility of wildfire.

It is during the next successional stage of 150 to 300 years that the threat of wildland fire increases. Because of overcrowding, some of the lodgepole pines begin to die, which allows sunlight through, spurring vegetative growth. After 300 years, the original lodgepole pines die, making the forest highly susceptible to wildland fire. For example, the lodgepole pine stands in the Yellowstone area during the 1988 fires were 250–350 years old.

When fire does not occur, lodgepole pines are sometimes gradually replaced by Engleman spruce and subalpine fir, although the successional pathway is site dependent. Fire regimes in lodgepole pine communities can be very irregular, thus community dynamics are difficult to predict.

Wildland fire management in lodgepole pine communities can be problematic. Because there tend to be high intensity crown fires, allowing lightning ignited fires to burn can result in fires which are difficult to contain within management units. Prescribed fire is difficult to manage for the same reasons, and can endanger nearby human communities. Fire suppression, however, creates a fuel buildup that is difficult to manage, and suppression is not consistent with maintaining ecological communities.

### **Southern Pine Communities**

Southern pine forests consisting mainly of loblolly, shortleaf, or longleaf pines are found from Texas east to Florida, and north to Maryland. Various species of oaks are often present, especially when fire has not occurred recently. Shrubs can also be present, such as saw palmetto and bayberry. Grasses are also common, such as little bluestem and wiregrass. Lightning ignited fires in southern pine communities are common. More frequent fires favor longleaf pines, which are more fire adapted. Less frequent fires tend to favor shortleaf and loblolly pines. Frequent fires also create pine savannahs when understory shrubs are burned away, favoring the establishment of grasses beneath the pines. In cases where fire does not occur for 25 years or more, such as when fire is removed from the system or on wet sites where fire seldom occurs, hardwoods such as oaks and hickories gradually replace the pines.



Ron Myers

Like many fire-adapted trees, longleaf pine requires mineral soil for seed germination, and thus ground fires prepare the seedbed by removing litter and releasing soil nutrients. The longleaf seedling grows slowly in the early years, devoting much energy to developing a thick root that is protected from fire, and to a dense protective layer of needles around the buds. Loblolly and shortleaf pines are less fire tolerant than longleaf pine, but the thick barks of these species also make them more fire tolerant than most other competitive tree species.

### **Jack Pine Communities of the Great Lakes Region**

A mixture of pines and other tree species is found in the forests of the Great Lake states. Red, white, and jack pine grow among paper birch and aspen. Grasses, forbs, and shrubs such as big bluestem, little bluestem, raspberry, blueberry, and huckleberry grow under the trees of these communities. The communities of the Great Lakes states have had many disturbances since European settlement, making it difficult to determine the “natural” state of these ecosystems.



Dave Currie

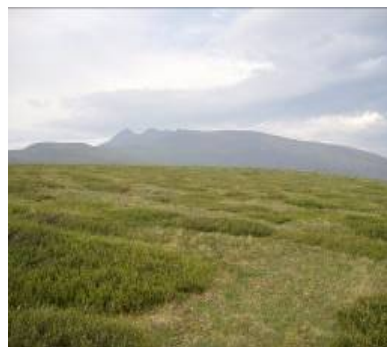
Jack pines are small trees, rarely exceeding 80 feet (about 24 meters) in height. They occur in poor soils, usually in open “pine barrens,” and often form savannahs when grasses are present on the thin soils. Fires occur in jack pine stands approximately every 125 to 180 years. Jack pine is well-adapted to fire. Serotinous cones, which have a waxy outer coating to protect the seeds, remain on the tree rather than dropping to the forest floor. Seeds can remain viable on the tree for 20 years or longer. When a fire occurs, the thick cone protects the jack pine seed from the intense heat. Jack pine seeds have been known to still be viable after exposure to heat at 1000 degrees Fahrenheit. That heat, however, opens the scales of the cone and releases the seed onto the ground where the fire has removed much of the existing vegetation and litter. Jack pine seeds require contact with mineral soil to germinate, so fire serves to prepare the seedbed, reduce competition from other plants, and release the jack pine seed. In addition, the short stature of jack pines makes crown fires a high likelihood; these very crown fires are necessary to release the seeds from dormancy.

When fire is withheld from jack pine stands, they are replaced by other boreal tree species, such as balsam fir, white spruce, and the hardwoods that occur in this ecosystem. Prescribed fire is used in jack pine stands in central Michigan in order to maintain habitat for the rare Kirtland's warbler, which requires young jack pine stands for nesting.

### **Alaska's Boreal Forest and Tundra**

Alaska is a vast landscape covered with boreal forest and tundra, all prone to wildland fire. The boreal forest is found in southern Alaska extending as far north as Fairbanks. Tundra is found in the higher elevation of this zone. Tundra extends from the Brooks Range north to the Arctic Ocean.

While the boreal forest has large vegetation (e.g., spruce and birch trees) and nutrient-laden soil, the tundra is a low landscape comprised of scrubby and herbaceous vegetation, often only a few inches high. Much of the tundra soil and its nutrients are locked in permafrost. Often the soil is shallow; in some places it is no deeper than the shallow root structure of the tundra vegetation.



On the south-facing slopes of the boreal forest are spruce, birch, and aspen. North-facing slopes contain mostly black spruce and birch. Both of these slopes exhibit a unique succession; the successional stages are greatly impacted by wildland fire.

Following a fire, cottongrass, fireweed, and other herbaceous plants invade. Shrubs and berries move in after a few years only to be replaced by more mature trees such as willow, aspen, and birch. Eventually the spruce gets established and dominates, usually until the next fire. The heavy accumulation of litter makes these forests most susceptible to fire.

Fires in the boreal forest and tundra typically burn in a patchwork, leaving a mosaic across the landscape. Time of year, moisture present, wind speed and direction at the time of the fire, and biomass accumulation since the last fire, etc., all add to the rendering of the mosaic.

Because of Alaska's cool year-round temperatures, vegetation decays at a very slow rate, thereby releasing nutrients at a very slow rate. Following a fire in the boreal forest or tundra, large amounts of nutrients are released. Plants exploit this opportunity, especially the early successional plants. In turn, wildlife exploit the lush growth. Consequently, Alaska's plant and animal communities are highly dependent on fire.

### **Atlantic Coastal Pine Barrens**

Source: <http://edc2.usgs.gov/publicationspdfs/ID559.2003.pdf> (US Geological Survey)

The Atlantic Coastal Pine Barrens is a disjunctive ecoregion covering approximately 6,200 square miles of the coastal plain of New Jersey, Long Island in New York, and Cape Cod, Martha's Vineyard, and Nantucket in Massachusetts, as well as nearby islands. Hydrology, soils, fire regimes, and vegetation combine to distinguish this ecoregion from neighboring ecoregions. The region has a wide variety of ecological systems, including cedar swamps, meadows, stunted pitch pine and oak forests, sphagnum bogs, heathlands, coastal salt ponds, dune systems, and the Nation's only maritime grasslands on Martha's Vineyard and Long Island.



The Nature Conservancy

Rainfall averages about 48 inches per year, but the soil is sandy, extremely porous, and drains very quickly. Soils and water in the ecoregion are generally very acidic, which limits naturally occurring flora, fauna, and suitable agricultural crops. Acid-tolerant shrubs, such as those of the heath family (blueberries, laurels, staggerbush), are common. Agricultural activity in many areas is limited to acid-loving crops, such as blueberries and cranberries, although parts of the ecoregion with richer soils support fruits, vegetables, and other crops. Aquatic fauna must also be acid-tolerant, resulting in relatively few species of freshwater fish and amphibians.

Historically, fire is the major disturbance factor influencing vegetation composition in the ecoregion. In its natural state, the landscape is swept by frequent fires, giving the advantage to species able to survive, such as pitch pine, scrub oak, heath shrubs, and bracken fern.

## Eastern Deciduous Forests (Source: [www.nearctica.com](http://www.nearctica.com))

***NOTE: Only certain species in these forests are fire dependent.***

The Eastern Deciduous Forest occupies the eastern half of the United States and southeastern Canada. The northern boundary of the Eastern Deciduous Forest blends gradually into the Northern Boreal Forest (Taiga) in New England and southern Canada. There is never a point where one can say "This is where the Northern Boreal Forest becomes the Eastern Deciduous Forest."

The western boundary is equally nebulous. A rough line of demarcation between the Eastern Deciduous Forest and the Prairie Biome is the Mississippi River. However this boundary really is ill-defined. Along the western margins of the Eastern Deciduous Forest, patches of forest and prairie intermingle depending on purely local conditions. In fact, small pieces of prairie reach as far east as Pennsylvania and Maryland. The southern boundary of the Eastern Deciduous Forest lies in central Florida. Southern Florida is given over to a Subtropical Region.



The Eastern Deciduous Forest is defined by the dominance of deciduous trees in the ecosystem. Deciduous trees are almost all angiosperms such as oaks, maples, beech, hickories, and birches that drop their leaves. Evergreen conifers do live in the Eastern Deciduous Forest, but are rarely as common or dominant as the deciduous trees except under particular types of local conditions.

The Eastern Deciduous Forest develops under a particular set of climatic conditions. Winters are cold, but relatively mild compared to the winters further north in the regions of the Northern Boreal Forest and the Tundra. The summer is similarly longer than further north and temperatures are higher. Possibly the most important climatic feature of the Eastern Deciduous Forest is precipitation, both rain and snow. Total precipitation throughout the year is higher in the Eastern Deciduous Forest than anywhere else in North America except for the tropical and subtropical areas to the south and the isolated spots of Temperate Rain Forest found along the Pacific Coast. Almost as important is the relative constancy of precipitation throughout the year.

The species composition of the Eastern Deciduous Forest has changed over time. From 3,500 to 1,500 years ago, oaks were the dominate species. As the amount of burning increased from 1,500 to 240 years ago, chestnuts became the dominate species. In the past 200 years, the amount of burning has decreased and oaks again are becoming the dominate species.

None of the previously described ecosystems exist as a blanket across the areas specified in their description. This is particularly true of the Eastern Deciduous Forest. Notice, for instance, that the Southern Pine Communities occur within much of the same geographic range as the Eastern Deciduous Forest. This area includes many different combinations of climate and geology from the central lowlands below the Great Lakes, across the Appalachian Mountains, and onto the coastal plain. One result is a general transition, from North to South, of species like beech and maple to more oak and pine, and, generally, more fire-adapted systems with progressively shorter fire return intervals. In the coastal plain, where much of the Southern Pine Community exists, evergreen species, including hardwoods, become much more common as well. Another aspect of this region's diversity, especially in the Appalachians, is a mixture of different communities on different slopes and elevations. As a result, fire-adapted oak and pine communities occupy some areas, while mixed hardwoods and fire-sensitive conifers occur on sites which burn less frequently.

## Fire Effects

The definition of **Fire Effects** is the physical, biological, and ecological impacts of fire on the environment. Both individual species and an integration of species and ecosystem responses to fire are influenced by fire season, fire behavior and characteristics, fuels, air quality, soils and watershed, plants, and wildlife. Variation in fire effects may occur within ecosystems because of differences in site characteristics, fuel conditions, and weather prior to, during, and after fire. A fire may have different effects upon the same site if it occurs in different seasons or within the same season but different fuel. Fires affect animals mainly through effects on their habitat, which can be either beneficial or harmful.

In addition, cultural resources including artifacts, structures, and traditionally significant gathering places from both prehistoric and historic eras can also be affected by wildfire. Therefore, you may need to discuss with your stakeholders the effects of a particular wildland fire in your area on both the cultural and ecological values and resources.

Understanding fire regimes, fire behavior and fire effects, and the differing needs of multiple species must be communicated to your audiences. Resource materials are available to guide you in developing messages on the ecological, physical and cultural impacts of fire:

Department of Agriculture, Forest Service, Rocky Mountain Research Station "Rainbow Series" on *Effects of Wildland Fire on Ecosystems*. This five-volume series covers air, soil and water, fauna, flora and fuels, and cultural resources (RMRS-GTR-42): [www.fs.fed.us/rm/publications/](http://www.fs.fed.us/rm/publications/).

National Wildlife Coordinating Group's (NWCG) publication *Fire Effects Guide* (NFES #2394): [www.nwcg.gov/pms/RxFire/rxfire.htm](http://www.nwcg.gov/pms/RxFire/rxfire.htm).

An example of fire effects is the impact to air quality caused by smoke. See **Chapter 3** for more information on this topic.

